The Egyptian Rheumatologist (2013) 35, 217–223

Egyptian Society for Joint Diseases and Arthritis

The Egyptian Rheumatologist

www.rheumatology.eg.net
www.sciencedirect.com

ORIGINAL ARTICLE

# Evaluation of left ventricular myocardial function in Egyptian patients with systemic lupus erythematosus: Tissue Doppler study and its relation to disease activity

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Received 29 April 2013; accepted 6 July 2013
Available online 21 August 2013

**KEYWORDS**

Systemic lupus erythematosus;
2 Dimensional and tissue;
Doppler echocardiography;
Systemic lupus erythematosus disease activity index

**Abstract** *Background:* Systemic lupus erythematosus (SLE) is associated with high cardiovascular morbidity and mortality. It is frequently underestimated by routine imaging techniques. Aim of the work was to determine if new echocardiographic imaging modalities like tissue Doppler, can detect abnormalities in left ventricular function in asymptomatic SLE patients.

*Patients and methods:* Fifty SLE patients were attending the rheumatology department of the Kasr El Aini hospital. All patients were subjected to cardiac, musculoskeletal examination, routine laboratory investigations. Twenty healthy age matched subjects were taken as controls. Ultrasound examination by two dimensional echocardiography and color tissue Doppler were performed on the patients and control to obtain the cardiac chamber diameters, systolic and diastolic myocardial velocities.

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[1] All authors contributed to the research and agree to the content, presentation, and decision to submit the manuscript.

[2] The Authors reported no conflict of interest. The authors alone are responsible for the content and writing of the paper.

Peer review under responsibility of Egyptian Society for Joint Diseases and Arthritis.

ELSEVIER Production and hosting by Elsevier

 http://dx.doi.org/10.1016/j.ejr.2013.07.002

*Results:* SLE patients have an increased prevalence of subclinical LV dysfunction. SLE patients with positive tissue Doppler findings were of old age, had long disease duration, high disease activity and nephritis.

*Conclusion:* Tissue Doppler velocities have been shown to be a sensitive tool in detecting early myocardial dysfunction before the occurrence of reduced left ventricular ejection fraction (LVEF).



## 1. Introduction

Systemic lupus erythematosus (SLE) is a multi organ autoimmune disease associated with high cardiovascular morbidity and mortality that primarily affects young women [1]. Patients with SLE have increased prevalence of subclinical left ventricular dysfunction which may be a prognostic indicator of cardiac mortality and morbidity. The mechanisms by which SLE might directly induce changes in the left ventricular structure are many fold and include underlying inflammatory processes leading to subclinical vasculitis, myocarditis or vascular stiffening and pre clinical coronary artery disease [2].

In this regard the standard method for evaluating cardiac function used in clinical practice often lacks sensitivity to detect myocardial abnormalities in SLE [3].

Tissue Doppler imaging is a non invasive technique widely used to detect subtle, asymptomatic myocardial function abnormalities. It is useful as it can identify early left ventricular dysfunction and allow reliable screening for subclinical cardiac involvement in patients with increased risk of cardiovascular disease [4]. Tissue Doppler measures regional systolic and diastolic myocardial velocities and has been used for quantitative analysis of global and regional myocardial function [5]. Myocardial velocity indicates the rate at which particular point that the myocardium moves toward or away from the transducer. In apical views the base of the heart moves toward the apex in systole and represents positive polarity and moves away from the apex to yield the early diastolic (e′) and late negative (a′) diastolic waves [4]. Myocardial performance index (MPI) is a simple, noninvasive and an easy method to estimate global left ventricular systolic and diastolic functions. MPI is the sum of isovolumetric contraction time and isovolumetric relaxation time divided by the ejection time [6].

We aimed in this work to determine if the new echocardiographic imaging modalities like tissue Doppler, can detect abnormalities in left ventricular function in asymptomatic SLE patients.

## 2. Patients and methods

Fifty patients with SLE and 20 age and sex matched healthy controls were enrolled into the study. All patients were recruited from the outpatient and inpatient sections of the rheumatology and rehabilitation department, faculty of medicine, Cairo university hospitals. They were diagnosed as SLE based on the revised criteria defined by the American college of Rheumatology [7].

### 2.1. Exclusion criteria

SLE patients with typical symptoms or signs of heart failure, significant valvular heart disease, history or symptoms of coronary heart disease.

All patients were subjected to full history taking, general, cardiac and musculoskeletal examination, body mass index($wt/ht^2$), routine laboratory investigations (complete blood count, liver and kidney function, lipid profile, and erythrocyte sedimentation rate), chest X-ray. Disease activity assessment by SLE disease activity index (SLEDAI) [8]. Data regarding the presence of hypertension, diabetes mellitus, and hyperlipidaemia were collected and recorded from patients and controls to assess the cardiovascular risk factors. None of our patients or controls was a smoker.

According to SLEDAI score we classified our patients into two groups: [8]; 30 Patients with SLEDAI > 10 denoting active disease and 20 patients with SLEDAI < 10 denoting inactive disease.

Cardiac function was assessed in all patients and controls by:

(1) The conventional two dimensional (2D) transthoracic echocardiography by which the left atrial, the left ventricular (LV) dimensions and septal wall thickness were measured according to the published recommendations of the American society of Echocardiography [9]. End-diastolic and end-systolic LV volumes and ejections fraction were measured using apical 4-chamber and 2-chamber views.
(2) Tissue Doppler: pulsed-wave tissue Doppler imaging was performed, the sample volume was placed on the lateral and septal mitral annulus in the apical 4-chamber view to measure the following parameters; peak systolic myocardial velocity(s), peak early (e), and late (a) myocardial diastolic velocities, isovolumetric contraction time (ICT) (which represents the distance between the end of diastolic velocity and the beginning of systolic velocity), isovolumetric relaxation time (IRT) (which represents the distance of the end of systolic velocity and the onset of diastolic velocity), ejection time (ET) (which is the duration of systolic velocity profil), myocardial performance index (MPI) (the sum of ICT and IRT divided by ET). The mean normal value of MPI is 0.39 ± 0.05 for the LV. in adults, values of the LV index <0.4 is considered normal .Higher index values >0.4 were considered as an index for cardiac dysfunction [6]. MPI by tissue Doppler has the advantage of assessing both regional and global myocardial performance. [9,10]

The study was approved by the local ethics committee and all participants provided informed consent.

Data were coded and entered using the statistical package SPSS version 15. Data were summarized using descriptive statistics: mean, standard deviation, minimal and maximum values for quantitative variables and number and percentage for qualitative values. Statistical differences between groups were tested using the Chi Square test for qualitative variables, independent sample t test for quantitative normally distributed variables while the Nonparametric Mann Whitney test was used for quantitative variables which are not normally distributed. Correlations were done to test for linear relations between variables. P-values less than or equal to 0.05 were considered statistically significant. To measure the association between the possible cardiac risk factors and myocardial dysfunction we used the OR. The 95% confidence interval (CI) is used to estimate the precision of the OR.

## 3. Results

This case control study compromised two groups; The 1st group included 50 female SLE patients. Their ages ranged from 18 to 50 years with a mean of 26.82 ± 6.96 years, their body mass index (BMI) ranged from 20 to 39 kg/m$^2$ with a mean of 26.86 ± 5.03 and their age of disease onset ranged from 17 to 40 years with a mean of 22.18 ± 6.29 and the duration of disease ranged from 1 to 15 years with a mean of 9.2 ± 4.91. The 2nd group included 20 age and sex matched healthy volunteers that served as the control. Their ages ranged from 17 to 52 with a mean of 27.5 ± 8.57, BMI ranged from 26 to 39 kg/m$^2$ with a mean of 27.4 ± 5.034.

By comparing between SLE patients and control, we found no statistically significant difference between both groups regarding their age, BMI, diastolic BP ($P$ = 0.568, 0.548, 0.120 respectively) however systolic BP was significantly higher in SLE patients compared to the control ($p$ = 0.001).

The clinical and laboratory characteristics of SLE patients are shown in Tables 1 and 2.

All our patients (100%) were on corticosteroids with a mean dose of 20 ± 9.34 mg/day and ranging between 5 and 40 mg., 23 (46%) patients were on a combination therapy of steroid, hydroxychloroquine and azathioprine, 16 (32%) patients were on steroid, hydroquine and cyclophosphamide, 11 (22%) patients were on steroid and hydroquine only, 25 (50%) of our patients were on antihypertensives, 6 (12%)of our patients were receiving anti diabetic treatment and 15 (30%) of them were on lipid lowering treatment.

### 3.1. Echocardiographic findings in SLE patients

#### 3.1.1. 2D echocardiography in SLE patients

Left Atrial dimension (LA) ranged from 2 to 4.7 cm with a mean of 3.23 ± 0.56, left ventricular end diastolic dimensions (LVED) ranged from 3.7 to 5.8 cm with a mean of 4.69 ± 0.56, left ventricular end systolic dimensions (LVES) ranged from 2. to 3.6 cm with a mean of 2.84 ± 0.42, septal wall thickness (SWT) ranged from 0.8 to 2 cm with a mean of 1.2 ± 0.29, posterior wall thickness (PWT) ranged from 0.9 to 1.9 cm with a mean of 1.45 ± 0.28, fraction shortening (FS) ranged from 29% to 50% with a mean of 39.4% ± 6.04%, ejection fraction(EF) ranged from 60% to 80% with a mean of 70% ± 7.70%, peak early diastolic velocity of mitral inflow(PW-E) ranged from 0.39 to 1 m/s with a mean of

**Table 1** The clinical characteristics of SLE patients ($n$ = 50).

| Clinical manifestations | No. of cases | % |
|---|---|---|
| *Constitutional manifestation* | | |
| Fever | 44 | 88 |
| Weight loss | 16 | 32 |
| Lymphadenopathy | 7 | 14 |
| *Mucutaneous manifestations* | | |
| Oral ulcers | 32 | 64 |
| Malar rash | 44 | 88 |
| Discoid rash | 8 | 16 |
| Photosensitivity | 29 | 58 |
| Alopecia | 8 | 16 |
| *Musculoskeletal manifestation* | | |
| Arthralgia | 32 | 64 |
| Arthritis | 13 | 26 |
| Myalgia | 26 | 52 |
| Myositis | 2 | 4 |
| *Vascular manifestations* | | |
| Raynaud's phenomenon | 8 | 16 |
| Cutaneous vasculitis | 2 | 4 |
| DVT | 2 | 4 |
| Neurological manifestations | | |
| Headache | 3 | 6 |
| Seizures | 1 | 2 |
| Psychosis | 3 | 6 |
| *Pulmonary manifestations* | | |
| Pleurisy | 22 | 44 |
| Dry cough | 7 | 14 |
| Pleural effusion | 3 | 6 |
| Hypertension | 25 | 50 |
| Diabetes | 6 | 12 |
| Dyslipidemia | 23 | 46 |

DVT, deep venous thrombosis.

**Table 2** Laboratory and immunological characteristics of SLE patients ($n$ = 50).

| Laboratory data | Range | Mean ± SD |
|---|---|---|
| Hb (gm/dl) | 6.2–14 | 10.44 ± 1.74 |
| WBC (cell/mm$^3$) | 2.3–15.5 | 7.11 ± 5.15 |
| Platelets (platelet/mm$^3$) | 17–788 | 272.96 ± 116.4 |
| ESR (mm/hr)(1st hr) | 20–150 | 69.42 ± 36.84 |
| AST (U/L) | 10–40 | 19 ± 8.19 |
| ALT (U/L) | 7 – 40 | 18.4 ± 3.29, |
| Albumin (g/dl) | 2.2–4.8 | 3.29 ± 0.57 |
| Creatinine (mg/dl) | 0.3–3 | 0.78 ± 0.47 |
| 24-h urinary protein (gm/24hr) | 0.01–3 | 1.14 ± 1.16 |
| TG (mg/dl) | 63–424 | 167.91 ± 86.43 |
| Cholesterol (mg/dl) | 137–431 | 220 ± 63.16 |
| Positive ANA (n, %) | 50 | 100 |
| Positive DNA (n, %) | 35 | 70 |
| Positive ACL (n, %) | 14 | 28 |
| Consumed C3 andC4 (n, %) | 29 | 28 |

Hb, hemoglobin; WBCs, white blood cells; ESR, erythrocyte sedimentation rate; AST, aspartate transaminase; ALT, alanine transaminase; TG, triglyceride; ANA, antinuclear antibodies; ACL, anticardiolipin; C3, C4, complement 3 and 4.

0.7 ± 0.15, peak late diastolic velocity of mitral inflow (PW-A) ranged from 0.4 to 1.35 m/s with a mean of 0.61 ± 0.17, and the ratio between E/A ranged from 0.72 to 1.59 m/s with a mean of 1.16 ± 0.28.

### 3.2. Tissue Doppler findings in SLE patients

*Tissue Doppler imaging findings at septum (TDI at septum)*: peak systolic myocardial velocity (S wave) ranged from 0.05 to 0.27 cm/s with a mean of 0.1 ± 0.04, peak early diastolic myocardial velocity (E wave) ranged from 0.05 to 0.27 cm/s with a mean of 0.12 ± 0.04, peak late diastolic myocardial velocity (A wave)ranged from 0.06 to 0.13 cm/s with mean of 0.1 ± 0.04, isovolumetric contraction time (ICT) ranged from 26 to 89 ms with a mean of 56.09 ± 16.62, isovolumetric relaxation time (IRT) from 28 to 96 ms with a mean of 66.22 ± 16.91 and the myocardial performance index ranged (MPI)from 0.2 to o.74 with a mean of 0.49 ± 0.11.

*Tissue Doppler imaging findings at lateral mitral annulus (TDI at mitral)*: peak systolic myocardial velocity ranged from 0.04 to 0.14 cm/s with a mean of 0.1 ± 0.01, peak early diastolic myocardial velocity ranged from 0.03 to 0.2 cm/s with a mean of 0.13 ± 0.01, peak late diastolic myocardial velocity ranged 0.01–0.16 cm/s with a mean of 0.12 ± 0.04, isovolumetric contraction time ranged from 37 to 100 m/s with a mean of 56.9 ± 16.62, isovolumetric relaxation time ranged from 37 to 107 m/s with a mean of 67.94 ± 18.13, and the myocardial performance index ranged from 0.27 to 0.98 with a mean of 0.53 ± 0.17.

Although, all the parameters of 2D echocardiography were within normal ranges in SLE and controls, the LA dimension was significantly larger in SLE patients than in controls ($p = 0.001$). Also SWT was significantly higher in SLE patients compared to controls ($p = 0.02$). Other parameters such as LVESD, LVEDD, PWT, EF, FS, PW-E, PW-A, and E/A showed no statistically significant difference between SLE patients and controls. (Table 3)

**Table 3** Comparison between SLE patients and controls regarding 2D echocardiography parameters.

| | SLE | Control | *p*-value | Significance |
|---|---|---|---|---|
| LA (cm) | 3.23 ± 0.56 | 2.58 ± 0.35 | 0.001* | S |
| LVESD (cm) | 2.84 ± 0.42 | 2.79 ± 0.25 | 0.536 | NS |
| LVEDD (cm) | 4.69 ± 0.56 | 4.65 ± 0.61 | 0.788 | NS |
| SWT (cm) | 1.2 ± 0.29 | 0.9 ± 0.29 | 0.020* | S |
| PWT (cm) | 1.45 ± 0.28 | 1.43 ± 0.15 | 0.548 | NS |
| EF% | 70 ± 7.7 | 71.7 ± 3.31 | 0.084 | NS |
| FS% | 39.4 ± 6.04 | 39.85 ± 4.53 | 0.618 | NS |
| PW-E (m/s) | 0.7 ± 0.15 | 0.69 ± 0.15 | 0.662 | NS |
| PW-A (m/s) | 0.61 ± 0.17 | 0.61 ± 0.14 | 0.983 | NS |
| E/A ratio | 1.16 ± 0.28 | 1.27 ± 0.78 | 0.896 | NS |

LA, left Atrial diameter; LVESD, left ventricular end systolic dimension; LVEDD, left ventricular end diastolic dimension; SWT, septal wall thickness; PWT, posterior wall thickness; PW-A, peak velocity of late diastolic mitral inflow; PW-E, peak velocity of early mitral inflow; EF, ejection fraction; FS, fractional shortening; E/A: the ratio between peak early (e), and late (a) myocardial diastolic velocities.
S: significant, NS: not significant.

There are statistically significant lower values of peak systolic myocardial velocity at the septum and lateral mitral annulus ($P = 0.004$ at both sites), peak early diastolic myocardial velocity at the septum and lateral mitral annulus ($p = 0.018$, 0.001 respectively) and peak late diastolic myocardial velocity at the septum and lateral mitral annulus ($p = 0.004$, 0.018 respectively) in SLE patients compared to the controls, while, there is no significant difference in isovolumetric contraction time at the septum and lateral mitral annulus between both groups ($p = 0.084$ at both sites). The isovolumetric relaxation time at the septum and lateral mitral annulus is significantly prolonged in SLE patients compared to the control ($p = 0.001$, 0.002 respectively), also the myocardial performance index at lateral mitral annulus and septum showed significantly higher values in SLE patients compared to the control ($p = 0.001$ at both sites). (Table 4)

Regarding the classification of the patient groups according to their SLEDAI scores, we found a statistically significant prevalence of hypertension among SLE patients with SLEDAI > 10 compared to those with SLEDAI < 10 ($p = 0.004$), while, no statistically significant difference was found between both groups regarding age, BMI, age of disease onset, disease duration, hyperlipidemia and diabetes ($p = 0.242$,0.312,0.341,0.22, 0.064,0.722 respectively).

On comparing patients with SLEDAI > 10 against those with SLEDAI < 10 regarding tissue Doppler parameters (as in Table 5) we found; statistically significant lower values of peak systolic myocardial velocity at the septum ($p = 0.019$) and lateral mitral annulus ($p = 0.013$), peak early diastolic myocardial velocity at the septum ($p = 0.013$) and lateral mitral annulus($p = 0.001$), peak late diastolic myocardial velocity at the septum($p = 0.013$) and lateral mitral annulus ($p = 0.002$) in patients with SLEDAI > 10 compared to those with SLEDAI < 10.

While, Isovolumetric relaxation time (IRT) at the septum ($p = 0.001$) and lateral mitral annulus ($p = 0.003$) was found to be prolonged in patients with SLEDAI > 10 compared to the other group. While isovolumetric contraction time (ICT) at the septum ($p = 0.235$) and lateral mitral annulus ($p = 0.125$) did not show significant difference between both groups.

Myocardial performance index (MPI) at the septum ($p = 0.001$) and lateral mitral annulus (0.002) showed higher values in patients with SLEDAI > 10 compared to the other group.

Fourteen (28%) out of the 50 SLE patients were ACL positive, ten out of them had high MPI (>0.4).A statistically significant difference was found in the MPI value between the group of SLE patients with positive ACL antibodies and those with negative ACL ($p = 0.01$)

### 3.3. Cardiac risk factors

The normal values for tissue Doppler parameters were not properly defined except for MPI. Upon correlation between tissue Doppler findings (represented by the MPI) and some clinical, laboratory findings we found; significant positive correlation between the MPI at the lateral annulus and the septum and each of the following; age of the patients ($p = 0.001$ at both sites), disease duration ($p = 0.01$, 0.001 respectively), 24 h urinary protein level ($p = 0.002$, 0.001 respectively) and SLEDAI ($p = 0.002$, 0.019 respectively)

**Table 4** Comparison between SLE patients and controls regarding tissue Doppler parameters.

| | SLE | Control | *p*-value | Significance |
|---|---|---|---|---|
| *TDI at septum* | | | | |
| S wave (cm/s) | 0.10 ± 0.04 | 0.12 ± 0.03 | 0.004* | S |
| E wave (cm/s) | 0.12 ± 0.04 | 0.15 ± 0.04 | 0.018* | S |
| A wave (cm/s) | 0.10 ± 0.04 | 0.12 ± 0.03 | 0.004* | S |
| ICT (ms) | 56.9 ± 16.62 | 56.8 ± 12.92 | 0.084 | NS |
| IRT (ms) | 66.22 ± 16.91 | 52.60 ± 11.65 | 0.001* | S |
| MPI (ratio) | 0.49 ± 0.11 | 0.34 ± 0.04 | 0.001* | S |
| *TDI at lateral mitral annulus* | | | | |
| S wave (cm/s) | 0.10 ± 0.01 | 0.12 ± 0.03 | 0.004* | S |
| E wave (cm/s) | 0.13 ± 0.01 | 0.15 ± 0.03 | 0.001* | S |
| A wave (cm/s) | 0.12 ± 0.04 | 0.15 ± 0.04 | 0.018* | S |
| ICT (ms) | 56.09 ± 16.62 | 56.8 ± 12.92 | 0.084 | NS |
| IRT (ms) | 67.94 ± 18.13 | 51.95 ± 18.86 | 0.002* | S |
| MPI (ratio) | 0.53 ± 0.17 | 0.37 ± 0.04 | 0.001* | S |

S, peak systolic myocardial velocity; E, peak early diastolic myocardial velocity; A, peak late diastolic myocardial velocity; ICT, isovolumetric contraction time; IRT, isovolumetric relaxation time; MPI, myocardial performance index; TDI, tissue Doppler; S, significant; NS, not significant; S*:highly significant.

**Table 5** Comparison between patients with SLEDAI > 10 and those with SLEDAI < 10 regarding tissue Doppler parameters.

| | SLEDAI > 10 | SLEDAI < 10 | *p*-value | Significant |
|---|---|---|---|---|
| *TDI of septum* | | | | |
| S wave (cm/s) | 0.09 ± 0.22 | 0.11 ± 0.04 | 0.019* | S |
| E wave (cm/s) | 0.11 ± 0.03 | 0.14 ± 0.047 | 0.013* | S |
| A wave (cm/s) | 0.1 ± 0.04 | 0.11 ± 0.02 | 0.013* | S |
| IRT (ms) | 73.8 ± 12.5 | 54.8 ± 16.4 | 0.001* | S |
| ICT (ms) | 64.3 ± 14.6 | 58.7 ± 12.65 | 0.235 | NS |
| MPI (ratio) | 0.54 ± 0.09 | 0.418 ± 0.101 | 0.001* | S |
| *TDI of lateral mitral annulus* | | | | |
| S wave (cm/s) | 0.1 ± 0.02 | 0.15 ± 0.09 | 0.013* | S |
| E wave (cm/s) | 0.11 ± 0.04 | 0.16 ± 0.03 | 0.001* | S |
| A wave (cm/s) | 0.09 ± 0.057 | 0.11 ± 0.037 | 0.002* | S |
| IRT (ms) | 74 ± 17.86 | 58.84 ± 14.65 | 0.003* | S |
| ICT (ms) | 67.03 ± 18.3 | 59.65 ± 12.7 | 0.125 | NS |
| MPI (ratio) | 0.58 ± 0.17 | 0.43 ± 0.15 | 0.002* | S |

TDI, tissue Doppler imaging; S, peak systolic myocardial velocity; E, peak early myocardial diastolic velocity; A, peak late myocardial diastolic velocity; ICT, isovolumetric contraction time; IRT, isovolumetric relaxation time; MPI, myocardial performance index; TDI, tissue Doppler; S: significant ($p < 0.05$), NS: non significant.

No association was found between the MPI and each of the cardiac risk factors; Dyslipidemia OR = 0.29 (95% CI: 0.08–1.04), diabetes OR = 0.87 (95% CI: 0.14–5.3), hypertension OR = 0.23 (95% CI: 0.06–0.8), anemia OR = 0.8 (95% CI: 0.23–2.7), and the presence of ACL OR = 0.63 (95% CI: 0.16–2.3).

## 4. Discussion

Cardiac involvement in SLE is prevalent in more than 50% of cases and includes myocarditis, pericarditis, valvular heart disease, coronary arterial disease and conduction abnormalities [11,12]. Because the symptoms of myocardial involvement are usually clinically silent compared with other cardiac involvement, its prevalence in 7–10% might have been underestimated [3].Also autopsy and cardiac magnetic resonance imaging showed a higher prevalence of myocarditis up to 40–70%[13].

Standard methods for evaluating cardiac function used in clinical practice often lack the sensitivity to detect myocardial abnormalities in SLE [14]. Tissue Doppler echocardiography is a sensitive echocardiographic technique for the quantitative assessment of subclinical myocardial dysfunction [15,16].

We conducted this study to evaluate the myocardial function in SLE by using a relatively new imaging modality (tissue Doppler) and correlate tissue Doppler findings with various clinical, laboratory and disease activity parameters in Egyptian SLE patients.

Our results showed that all 2D echocardiography parameters were within the normal range in SLE patients, however we reported statistically significant larger LA dimension in SLE patients compared to controls (3.23 ± 0.56 vs. 2.58 ± 0.35, $p = 0.001$). Similar findings were reported in the following

studies: [17] (3.62 ± 0.67 vs. 3.28 ± 0.47, $p = 0.01$), [18] (3.41 ± 0.48 vs. 3.14 ± 0.40, $p = 0.05$) and [19] (3.33 ± 0.34 vs. 3.06 ± 0.29, $p = 0.001$).

Also, on measurement of septal wall thickness, it was significantly higher in our SLE patients compared to the control (1.2 ± 0.29 vs. 0.9 ± 0.29, $p = 0.02$). Similar results were reported in the following studies; [17] (0.92 ± 0.18 vs. 0.88 ± 0.15, $p = 0.05$), [18] (0.92 ± 0.09 vs. 0.10 ± 0.11, $p = 0.05$), [19] (0.94 ± 0.12 vs. 0.84 ± 0.06, $p = 0.001$), and [20] (0.96 ± 0.17 vs. 0.86 ± 0.15, $p = 0.001$).

No statistically significant difference was found regarding the other 2 D echo parameters as LVESD, LVEDD, PWT, EF, FS, PW-E, PW-A, and E/A in the SLE patients compared to the controls. These were found in other studies [18,19].On the other hand, different results were reported by other authors [17,20]. This could be attributed to racial differences and to the small number of patients included in our study.

Regarding tissue Doppler findings, peak systolic velocity was significantly lower in SLE patients compared to the control at the level of septum (0.10 ± 0.04 vs. 0.12 ± 0.03,) and at the lateral mitral annulus (0.10 ± 0.01 vs. 0.12 ± 0.03,), our results were supported by the following studies; [18] (0.29 ± 0.9 vs. 0.39 ± 0.7 at septum) and (0.39 ± 1 vs. 0.51 ± 0.8 at lateral mitral annulus), [19] (0.65 ± 2.35 vs. 0.86 ± 2.3 at septum) and (0.75 ± 2.41 vs. 1.031 ± 2.95 at lateral mitral annulus) and [20] (0.78 ± 1.54 vs 0.86 ± 0.92, at septum) and (0.92 ± 2.2 vs. 1.1 ± 1.66 at lateral mitral annulus).

The peak early diastolic myocardial velocity (E wave) was found to be significantly lower in SLE patients compared to the control (0.12 ± 0.04 vs. 0.15 ± 0.04, at the septum), and (0.13 ± 0.01 vs. 0.15 ± 0.03 at the lateral mitral annulus). Similar results were reported by others; [17–19].

The peak late diastolic myocardial velocity (A wave) was significantly lower in SLE patients compared to the control (0.10 ± 0.04 vs. 0.12 ± 0.03, at the septum), (0.12 ± 0.04 vs. 0.15 ± 0.04 at the lateral mitral annulus). We had an agreement with other studies [17,18].

Regarding the myocardial performance index, it was significantly prolonged in SLE patients compared to controls (0.49 ± 0.11 vs. 0.34 ± 0.04 at the septum) and 0.53 ± 0.17 vs. 0.37 ± 0.04 at the lateral mitral annulus, and was similar to that reported by other studies [14], in contrast to others [19].

Fourteen out of our 50 SLE patients were positive for ACL, 10 out of them had high MPI values. Antiphospholipid antibodies could represent only one of the pathogenetic factors of the cardiac lesions in SLE patients [21]. Similar to the study [22], we found a significant difference in the mean MPI value between SLE patients with positive ACL and those with negative antibody ($p = 0.01$).

On comparing tissue Doppler findings between active and inactive SLE groups, we found statistically significant lower values of peak systolic myocardial velocity at the septum ($p = 0.019$) and lateral mitral annulus ($p = 0.013$), peak early diastolic myocardial velocity at septum ($p = 0.013$) and lateral mitral annulus ($p = 0.001$), peak late diastolic myocardial velocity at the septum ($p = 0.013$) and lateral mitral annulus ($p = 0.002$) in the active group compared to the inactive group. It has been reported [20], that the peak systolic velocity was significantly lower at the septum (6.68 ± 0.99 vs. 8.22 ± 1.51) and at the lateral mitral annulus (7.82 ± 1.92 vs. 9.82 ± 2.05) in the active patients compared to those with inactive disease. Also the isovolumetric relaxation time (IRT) at the septum ($p = 0.001$) and the lateral mitral annulus ($p = 0.003$) was found to be prolonged in our active group compared to the inactive group, this finding is supported by other studies [23,24].

Other studies [18,25] reported different findings as they did not find significant differences between active and inactive groups regarding the tissue Doppler parameters. However, the active patients in the study [18] showed significant reduction in LV function when measured by strain rate and strain imaging that are technological advancements that have been developed as a means to objectively quantify regional myocardial function. So they concluded that strain rate was better than tissue Doppler in detecting differences in LV function in SLE patients with active disease.

We can conclude that the SLE patients have an increased prevalence of subclinical LV dysfunction. Although, the parameters of 2D echocardiography were within normal range in SLE patients, systolic and diastolic velocities of the LV measured by tissue Doppler were significantly impaired in SLE patients compared to controls.

Regular monitoring of cardiac function by tissue Doppler is recommended for SLE patients with the following risk factors: old age, long disease duration, high disease activity.

## Conflict of interest

The authors declare that there is no conflict of interest.

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